A BRIEF HISTORY OF THE EARLY DEVELOPMENT OF THE DEPARTMENT OF ENGINEERING MECHANICS OF THE OHIO STATE UNIVERSITY

Mechanics Instruction Prior to Establishment of Department

The Ohio State University was established in 1870. However, the Third Annual Report of the Trustees, for the year ending June 30, 1874 indicates that the University opened for student enrollment on September 17, 1873. To greet the students was the President, Edward Orton, who was also Professor of Geology and six other faculty members. Of interest to us are two of these, F. W. McFarland, Professor of Mathematics and Civil Engineering and Dr. T. C. Mendenhall, Professor of Physics and Mechanics.

The instruction in Physics included the following courses:

First year, second term - Mechanics of solids

First year, Third term - Mechanics of liquids and gases

Second year, First term - Heat

Second year, Second term - Electricity

Second year, Third Term - Acoustics and Optics

Third year, First term - Practical Mechanics, Study of Structures, Strength of Materials, etc.

To trace the instruction of students in what we now call Engineering Mechanics, we note that Stillman W. Robinson, who earned the degree C. E. at the University of Michigan in 1863, had now joined the staff as Professor of Physics and Mechanics, and courses were given in Analytical Mechanics, Strength of Materials and Mechanical Laboratory. This appears in the catalog for the year ending 1878. Robinson had been Professor of Mechanical Engineering and Physics at the University of Illinois from 1870 to 1878, and a later faculty list indicates his title as Professor of Mechanical Engineering and Physics at Ohio State from 1878 to 1881 and Professor of Mechanical Engineering at OSU from 1881 to 1895, when he apparently resigned.

In the list of faculty for 1881-82, T. C. Mendenhall, Ph.D., is shown as Professor of Physics and S. W. Robinson, C. E. as Professor of Mechanics. In his departmental report in 1882-83 to the Trustees, S. W. Robinson, Professor of Mechanical Engineering gives Analytical Mechanics as having an enrollment of three students.

The course in Civil Engineering, (which we would call the curriculum) in 1879, list Analytical Mechanics in the third year, first term, and Strength of Materials in the fourth year, first term. R. W. McFarland was still Professor of Mathematics and Civil Engineering, and S. W. Robinson was Professor of Physics and Mechanics. The catalog, apparently, is not consistent in titles or any more accurate than it is today.

For the academic year 1882-83 Analytical Mechanics was listed as a Mechanical Engineering course and given in the Fall and Winter terms, and Strength of Materials (called in one catalog Resistance of Materials) was offered in the Spring term. The enrollment was ten in Mechanics and four in Strength. Later, (about 1897) these courses take on numbers and the three terms of engineering mechanics are listed as M.E. 6,6, and 7.

A typical curriculum of this period is the one in Civil Engineering, as reported to the Trustees for the year ending June, 1900. The three terms of the second year require

Math 18 (5) Space Analysis	Math 19 (5) Calculus	Math 20 (5) Calculus

while the third year includes

Mech Eng 6 (5) Mechanics	Mech Eng 6 (5) Mechanics	Mech Eng 7 (5) Strength of Materials

and listed under the departments of instruction are the first real descriptions of these courses.

M.E. 7 (5) Recitation and Lectures on the elastic and ultimate resistance of the materials of engineering to stress and their use in structures and machines. Lectures, elementary hydraulics and the flow of water through orifices and pipes, over wires and in streams and on measuring the same. Third term, third years, same as M.F. 6.

One may be inclined to conclude from the above, that statics and dynamics (perhaps ?) was rather a "set" or "standard" course in the early days of engineering education and the content was so obvious that it was considered unnecessary to delineate it. Perhaps not all of the two terms were devoted to this, and strength of materials was introduced as soon as the statics (or equilibrium) was finished. The last portion of the third term was then given over to fluids, or liquids only, or hydraulics, as it was usually called.

Then begins a metamorphosis in the curricula of early engineering education. The Trustees Report for the year ending June, 1901 gives the first clue to the future plans where a change in title is given to James E. Boyd - from Assistant Professor of Physics to Associate Professor of Mathematics. The Civil Engineering curriculum substitutes in the third year, Mathematics 6 (5), 6 (5) and 7 (5) and notes these courses were formerly in Mechanical Engineering.

The faculty in engineering, if it may be so designated, apparently had some autonomy as indicated by developments reported for the year 1901-02 and subsequent years. C. N. Brown, head of Civil Engineering, and Dean of the College died suddenly on March 6, 1902. The report states that "At the beginning of the year just closed he was elected by his associates in the faculty, Dean of Engineering."

Brown had been an assistant in mathematics and civil engineering under Professor Robert W. McFarland in 1884, and a year later was Assistant Professor of Civil Engineering, which seems to be the beginninf of a separate department.

The enrollment for 1901-02 shows

Mathematics	First Term	Second Term	Third Term
Mechanics 26,27	67	63	53

and indicates a new numbering of the courses. The following year, 1902, shows other changes, due, no doubt, to the influence of Professor Boyd on the curriculum and standards of instruction. We find now in the third year

Math 71 (5)	Math 72 (5)	Math 73 (5)
Statistics*	Strength of Materials and Kinetics	Kinetics and Hydraulics

with * changed to Statics in 1902-03 in the catalog. This confusion in the editor's office has, apparently a long history.

The enrollment increased in 1903-04, and engineering was attracting more students:

Mathematics	First Term	Second Term	Third Term
Mechanics 71, 72,73	109	105	99

Formation of Mechanics Department - 1906

Report of Dean Edward Orton Jr., College of Engineering to President William Oxley Thompson; May 15, 1906.

"The other departmental change which we have been anxious to carry into effect, is the work in Analytical Mechanics. Professor J. E. Boyd has been in charge of this work for four years, but the work has been carried on under the administrative control of the Department of Mathematics. Professor Boyd is peculiarly fitted by training and taste to take up experimental investigations in the field of Mechanics of Materials, or the testing of the raw materials of Engineering construction, and in the application to these materials of methods of mathematical analysis, which the test book courses had always given.

"The equipment of the University in its apparatus for testing materials of construction is meager, and improvement is urgently needed in this respect. The Department of Mechanical Engineering, though greatly overcrowded, now gives instruction in this work, which belongs more specifically in the field of analytical mechanics.

"It is now proposed to combine the work in Analytical Mechanics and Strength of Materials into a new department in which shall be included the theoretical work now given in the Department of Mathematics and the practical work now given in the Department of Engineering.

It is further recommended that the equipment for teaching this work should be considerably enlarged at the earliest date possible. This will enable the junior year of our engineering courses to be strengthened by the introduction of laboratory work in mechanics which should extend through the year. This will secure to every engineering graduate practical familiarity with the materials of

construction and familiarity with the use of mathematics in considering them. It is hoped that Professor J. E. Boyd will be able to accomplish a very material improvement under this new arrangement over what has been possible under the former divided control.

"In this connection, it should be said that adequate provisions for such a department will include a laboratory of considerable size and a considerable increase in the number of testing machines, as well as some lecture room apparatus designed to illustrate the principles in class work. The work could be placed temporarily in any building where room is available, but in many respects the new building for the Departments of Electrical and Mechanical Engineering is the most suitable for its permanent home, and it is hoped that the plans for this building will make permanent provision for the work in this department."

(Later in his report, in discussing courses of study, Dean Orton says:)

"These changes in the freshman and sophmore courses and that in the third year relating to the teaching of Mechanics of Materials should apply to all engineering courses. It is not desirable or possible for me to suggest detailed changes in the special work of the various technical courses, but is is strongly felt that the technical instruction given should comprise none of the first year, not to exceed five hours per week in the second year, and that at least seven hours per week in the third year should be common to all branches of engineering. This makes about 60 percent of the courses common to all and allows about 40 percent of special work to be inserted, which is as much as should be included in a four years' engineering course."

First Budget of the Department

Board of Trustees Reports of 1905-06

James E. Boyd reelected Associate Professor Mathematics at $1700. He was also secretary of the Entrance Board.

Budget for 1906-07

Department of Mechanics

James E. Boyd, Professor	$2100
E. F. Coddington, Asst. Prof.	1300
J. H. Kindle, Fellow	300
Current Expense	10
New Equipment	200

Exerpts from Departmental Reports to the President and Board of Trustees, for the year ending June 30, 1907

Department of Mechanics
Professor J. E. Boyd

"The Department was organized in 1906 with myself as Professor, Dr. E. F. Coddington as Assistant Professor, and J. H. Kindle as Fellow.....

"The work of the department has been carried along practically the same lines as heretofore. There has been the advantage that we have had the exclusive use of a classroom in the Mines Building and some money for equipment. This room is one of thsoe intended for the museum of Mining and Metallurgy. It is 34 feet by 31 feet and is provided with 90 feet of blackboard, and is admirably adapted for our use. During the Fall and Winter terms the other sections reciting at the same hour have used the lecture rooms of Metallurgy and Ceramics. During the present term we are holding two sections in the Law Building and one section in the lecture of the Mining Department.

"When experimental work is given, the two sections at the same hour have either exchanged rooms, or two sections have been brought together in the same room for a part or all of a period. The ideal plan would be to have two rooms similar to this one with a small apparatus room between them. It is hoped that this arrangement can be secured in the proposed Mechanical Building.

"The room is provided with a heavy lecture table, to which is attached a frame for supporting the apparatus. The apparatus which we have consists of a few simple pieces which have been designed or adapted for our purpose. These include a delicate platform scales, spring balances, a screw which combined with knife edges and beams enables us to test small beams and columns, clamps, pulleys,

ropes and weights. Among the special apparatus we have:

"A graduated circle three feet in diameter to determine angles in the demonstration of forces in equilibrium.

"A 'frictionless rod' provided with rollers at the ends.

"Clamps to be used with knife edge in adjusting the load to the center of a column with 'round ends.'

"Apparatus for demonstrating the acceleration of the Atwood machine.

"An Atwood machine mounted on a balance beam with one cord in the vertical plane of the knife edge, thus measuring directly the accelerating force on the mass supported by the other cord.

"In these experiments it is our aim to give a few demonstrations on a sufficiently large scale to bring out the details and have the class work out the results at once. Usually members of the class are asked to take the actual measurements.

"The results have been quite satisfactory. We believe that the students have gained a better idea of the physical basis of mechanics than heretofore.

"The present year has been devoted to bringing up the work of the junior Engineering Mechanics (which is elected by several Arts students and a few graduates) and we have made no attempt to offer any advance courses. We hope after another year to be prepared to give one graduate course which shall consist of considerable theory together with a limited amount of laboratory work.

"Publications. At the December meeting of the American Association for the Advancement of Science I read a brief paper paper on 'Theory of Horizontal Compression Members with Eccentric Pin Connections' which was afterward (April 11, 1907) printed in the Engineering News."

Principal Faculty Member 1906-1956

We now appraise the men who were chosen to pioneer the work in Mechanics, as well as we can from the faculty listings.

Professor James Boyd received his B.Sc. in mathematics and physics from OSU in 1891. His M.Sc. was in physics from Cornell University in 1896, after serving as an assistant in physics at OSU from 1891 to 1895. He was also a student at Sibley College at Cornell in 1895. Upon returning to this university he was assistant professor of physics 1896-1901; Associate Professor of Mathematics 1901-05, and Professor of Mechanics from 1906, when the department was established until his retirement in 1936.

Professor Edwin F. Coddington received his C.E. degree from OSU in 1896 and his M.Sc. in 1897. He was an assistant in Astronomy for a period. His Ph.D. was from the University of Berlin in 1902, where he discovered an asteroid and computed its orbit for his dissertation subject. He returned to his alma mater in 1902 as Assistant Professor of Mathematics, and was transferred to the nde Department of Mechanics, when it was established. He was made a Professor in 1912, and from 1915 to 1920 he was Acting Dean of the College of Engineering, during a leave of absence of Edward Orton Jr. (who incidently never returned to this position).

Both Boyd and Coddington had reputations as excellent teachers, and pioneers in their field. In order to improve instruction, Boyd wrote one of the early modern texts in Strength of Materials in 1911. It was revised into new editions in 1917, 1924 and 1935. The fifth edition was a revision in 1950 by S. B. Folk, a professor in the department, who had joined the staff in 1926. Folk was a graduate of OSU with a B.C.E. degree in 1920, and a M.Sc. from Case Institute of Technology in 1923. He had teaching experience at Case and at North Dakota State University.

Boyd also wrote a text in "Mechanics" in 1921, which was revised in 1930. The 3rd edition was a revision by P. W. Ott, a professor in the department, who joined the staff in 1919. Ott received his B.Sc. in C.E. from the University of Illinois in 1917 and was Captain, Corps of Engineers 1917-19. He had extensive engineering and consulting experience during his association with OSU. He received his M.Sc. degrees in 1930, this being the first graduate degree given by the Department of Mechanics.

Coddington was a man of broad interests, who never lost concern for the mathematics which the student ought to have at this use. In the 1920's he requested permission to teach calculus to engineers, and developed new approaches and examples to drive home the art of solving problems. He became (1925) Professor of Geodetic Engineering and devoted most of the remaining time at the university teaching civil engineers.

Professor Boyd was recognized nationally for his teaching methods when he was asked by Dean Harry Hammond of Penn State University to serve as one of the permanent staff members at a school for 40 young mechanics teachers at Cornell University for three weeks during July, 1927. These young teachers and another group, of 40 at the University of Wisconsin, conducted concurrently and attended by Prof. Folk, were selected by a national committee of the Society for the Promotion of Engineering Education, and supported by funds from the Carnegie Corporation of New York. This was the first effort by the (now named) American Society for Engineering Education, and was instituted because of a feeling among educators that the teaching of mechanics was one of the most difficult subjects in engineering, and that great improvement could result from a "seed program" with young men in the classes.

Another school of the same type was held under the auspices of Iowa State University in 1950. The purpose was very similar, with the foremost idea being to bring ideas and techniques tc young men who joined the teaching field after the war. Professor Folk was one of the lectures at this symposium.

Professor Boyd asked to be relieved as chairman of the department and was succeeeded by Percey W. Ott, who held this post from 1934 to 1952.

In education, especially engineering education, it seems that great strides are taken at intervals, interspersed with assimulation and refinement of the changes. It was mentioned earlier that Professor Boyd gave up his administrative position as chairman of the department in 1934 and was succeeded by Professor P. W. Ott, who held the position until 1952. Until 1945, the staff was mostly permanent and unchanged, for about 11 years. Besides Ott, Boyd and Folk, all of whom have been mentioned earlier, there were three other alert innovators who contributed much to the organization and teaching of Mechanics. They were Professor Ralph W. Powell and Edgar C. Clark and LeRoy Tucker.

Powell received his B.S.C.E. from Michigan State, his M.Sc. in hydraulics from Cornell University, and his Ph.D. from Yale. He then spent eleven years at the College of Yale in China, returning to the states in 1927 when the College was closed. He joined the department that year, and was a prolific scholar, publishing in many engineering journals, his research in fluid mechanics. He was the author of "An Elementary Text in Hydraulics and Fluid Mechanics" which went through three editions, in 1938, 1940 and 1951.

Clark was a graduate from the University of Kansas with a B.S.C.E. and a M.Sc. degree from the University of Illinois in Theoretical and Applied Mechanics, who joined the staff in 1929. He contributed many ideas and small pieces of apparatus to the laboratory work.

Tucker was an A.B. graduate from Washburn College, B.S.C.E. and M.Sc. from the University of Illinois In T. and A.M. who became a staff member in 1934. Later he became interested in Soil Mechanics and foundations, and earned his Ph.D. in Geology in 1954.

The stride that occurred during 1952-53 was a period of study, evaluation, and reconstruction of the department. Due to the sudden and untimely death (April 24, 1952) of Charles E. MacQuigg, Dean of the College of Engineering, and while the College was administered by Acting Dean Lawrence D. Jones (with assistance of a College Executive Committee), the department was unable to select a new chairman, after the expiration of Professor Ott's term of office. On May 20, 1952 the Acting Dean notified the department that, until a new Dean had been selected the department would be under the control of an Administrative Committee consisting of C. T. West, S. B. Folk and Walter L. Starkey, Professor of Mechanical Engineering.

The Administrative Committee made its report to the College at the end of the year 1952-53, and with considerable material gathered from visitations at other midwestern universities, recommended that the department submit a proposal to the Graduate School requesting permission to offer work leading to a degree of Ph.D.

Dean Gordon B. Carson, who had assumed the administrative duties of the College on July 1, 1953, enthusiastically approved of this proposal and agreed to support the department with funds for staff and equipment. The Dean also abolished the Administrative Committee and recommended the appointment of Charles T. West as Professor and Chairman.

West was gradauted from OSU in 1939 with the degree B.C.E. and held the Robinson Fellowship for graduate work in engineering. After a five year leave of absence as a Naval officer, he returned and received his M.Sc. in 1946. Cornell University granted him a Ph.D. in 1951. He has provided enthusiastic leadership during the formulative period when the transition to graduate work was undertaken. He is a man of the broad training and experience which is so necessary to a well rounded development of the department.

Space Facilities

Reports in the Board of Trustees meetings indicate that the university has always been handicapped by lack of budget and space to carry out its unique function as the people of Ohio assume it is being carried out. First also have destroyed buildings and caused doubling up and crowding of departments"temporarily", while the university awaited adequate appropriations to rebuild. Among the losses were three chemistry buildings, the one in February, 1904, seriously crippling the engineering instruction because several engineering departments were housed in it. The Trustees Report says the temperature was 10° below zero the night of the fire, the fire department was slow in arriving, the steam pumpers delayed in getting into action, and the firemen afraid of chemical explosions stayed far back from the building. The Mines Building (later called Lord Hall) was constructed about this time, and when the Department of Mechanics was established in 1906, housed the new department inadequately in respect to private offices and laboratory facilities.

Earlier the establishment of a laboratory in the Industrial Engineering Building, together with offices and classrooms was mentioned. From 1924 until 1965 this building comprised all or part of the space available to the department. The laboratories were housed there until Boyd Laboratory was completed in 1965. Classrooms, however, were at a premium, and the professors were forced to teach in Journalism, Lord Hall, Brown Hall, Robinson Laboratory, Veterinary Clinic, Derby Hall, Engineering Experiment Station and in temporary wooden barrack erected west of the Industrial Engineering building at the close of World War II and used until the site was needed for the Civil-Aeronautical building.

Some relief was provided in 1958, when Education and Electrical Engineering vacated the second floor of the Communications Laboratory, a two story wood and

brick structure which was hastily thrown together during World War I to house an airplane engine laboratory for training men in the Air Corp (as it was then called). Education moved to the new wing of Arps Hall and Electrical Engineering to new space in Caldwell Laboratory. Engineering Mechanics (the new name acquired in June 1954) fell heir to three classrooms and eleven offices, a great improvement in space, but poorly ventilated and hot in the summer because of the black tar paper roof which always leaked during a hard rainstorm.

Boyd Laboratory was constructed by remodeling a three story brick and reinforced concrete addition to the Engineering Experiment Station, built to house the State Highway Testing Laboratory at a cost of $92,000 in 1932. It was originally designed for four stories but funds were not sufficient and the top floor was never built. After the Highway Department moved to a much larger site and building on W. Broad Street, the building stood empty for more than one biennium, because the legislature appropriated not one cent for any remodeling or construction.

In June 1965 the department moved from Communications and Industrial Engineering Laboratories. Boyd Laboratory was well planned and constructed so that it was adequate for the department needs at the time. This seems to be customary in educational facilities; due to budgetary restrictions of state appropriations, no expansion is ever provided for. The 22,000 square feet is divided into three classrooms, 17 offices, 10 laboratories, graduate student room, study room, faculty conference room and computer room. It is fully air conditioned.

Laboratory Facilities

Board of Trustees Report for Year Ending June 1925
Report of E. A. Hitchcock, Dean of Engineering

"Professor Boyd's materials laboratory went into service with the beginninr of the autumn quarter. All equipment was installed during the summer quarter, its erection being personally supervised by Professor Boyd. There are now six testing machines of different types and capacities in this laboratory, and to these another is being added, purchased through the Morrill Fund."

The story about the origin of the laboratory may not be recorded fully in any one set of records. The Mechanics Department has been housed in the Mines Building, later called Lord Hall, until 1923-24. The Journalism Department occupied the second floor, north wing of the Shops Building, including a large room with printing presses. A new two story building for Journalism was erected at Neil and 18th Avenue and all equipment was vacated from the Shops Building, later renamed Industrial Engineering Building.

Sometime shortly before June 30, 1923 Dean Hitchcock notified Professor Boyd that he had a residue of $10,000 in the equipment budget and that if the Professor could encumber this amount for the long awaited testing laboratory, he could have it. As Professor Boyd related the incident, he had something like thirty days to contract for the initial testing equipment. The six machines referred to by Dean Hitchcock in his report were a 100,000 pound, four screw Olsen Universal capable of taking a five foot column, a 6,000 in.-lb. Riehle torsion machine, an Izod impact machine, and three 50,000 pound University testing machines. For instructional use Boyd purchased three different types: a two screw Riehle, a four screw Olsen, and a three screw Olsen. These were delivered and installed and calibrated during the summer of 1924. The Morrill Fund was used to buy a three screw Universal Olsen with additional gear box making it capable of being used for any of ten speeds of the movable crosshead. Shortly thereafter a standard R. R. Moore fatigue machine was added.

While the department was housed in the Industrial Engineering Building, it acquired two 60,000 pound hydraulic universal testing machines and initiated development of supporting machine shop facilities.

Since moving into Boyd Laboratory in 1965, the department has acquired extensive electronic strain measuring devices to facilitate data collection for static testing. It also has a minimal photoelastic laboratory with darkroom and oven facilities.

A well-equipped laboratory has been developed in the department for experimental studies of vibration and wave propagation phenomena. Available facilities enable response of both structures and materials to a wide range of dynamic loading to be studied. Areas under active investigation include vibrations of plates and shells, high velocity impact, transient loading of massive structures, parametric vibrations, structural vibrations, magnetoelasticity, dynamic material properties and power ultrasonics.

Graduate Programs

Mentioned earlier was the fact that P. W. Ott in 1930 was awarded the degree M.Sc., the first such degree earned by one majoring in his graduate work in this department.

The first Ph.D. degrees for work in Engineering Mechanics were granted in August 1957 to Robert Goodstein and Francis W. Niedenfuhr. Approval of a Ph.D. program by the Graduate School was received in 1954.

Ph.D. Degrees Awarded

Name	Date
Goodstein, Robert	1957
Niedenfuhr, Francis	1957
Leissa, Arthur W.	1958
Bert, Charles W.	1961
Carlson, Robert L.	1962
Mahig, Joseph	1962
Chin, Paul B.	1962
Kozik, Thomas J.	1962
Kulbert, Lewis E.	1963
Foye, Raymond L. Jr.	1963
Barnes, R. A.	1963
Korda, P. K.	1964
Bussman, Dale R.	1964
Lo, Christopher C.	1964
Poli, C. R.	1965
Clausen, William E.	1965
Stillman, William E.	1965
Roth, Don L.	1966
Dreher, John	1966
Visser, Cornelis	1966
Kennedy, James C.	1967
Fromme, Joseph A.	1967
Wilson, James F.	1967
Stein, Robert A.	1967
Whitney, James M.	1968

M.Sc. Degrees Awarded

Name	Date
Ott, P. W.	1930
West, C. T.	1946
Goodstein, Robert	1949
Morledge, Joe	1949
Mase, George	1949
Allgood, Jay	1951
Daye, Jerry	1951
Thurston, Gaylen	1951
Jenkins, David	1954
Sprung, Norman	1956
Lambert, Warren G.	1957
Kozik, Thomas J.	1957
Rieser, Elmer P.	1957
Chin, Paul B.	1957
Stein, Robert A.	1959
Garibotti, Joseph	1959
Mahig, Joseph	1959
Mobley, Milton	1959
Barnes, Robert A.	1959
Hammond, Gary	1961
Clausen, William	1961
Roth, Donald	1961
Burton, Bruce	1962
Bishop, Loren	1962
Gerdeen, James	1962
Kennedy, James C.	1962
Skubiak, Michael T.	1963
Koper, Raymond M.	1963
Visser, Cornelis	1963
Wallskog, Alan G.	1963
Clayton, K. I.	1963
Davis, R. E.	1963
Wells, L. T.	1963
Baker, Don L.	1964
Adkins, Richard	1964
Haas, John	1964
Matson, Charles B.	1964
Whitney, James	1964
Horstmeier, Heinz	1965
Pinsent, Hilary	1965
Rogers, Lynn	1965
Bierly, C. W.	1966
Earhart, James W.	1966
Blackburn, C. L.	1966
Frost, William G.	1966
Bruns, G. H.	1966
Lantz, Paul	1966

M.Sc. Degrees Awarded (Contd.)

Name	Date
Brown, Joe H.	1966
Couch, Robert D.	1966
Elsbernd, Gerald	1966
Brewer, Howell K.	1967
Logan, James D.	1968
Simons, Donald	1968
Bell, Frederick	1968
Johns, Thomas G.	1968
Shieh, Ming Kang	1968
Seifrick, John M.	1969
Abraham, Gerald	1969
Koscinski, Daniel P.	1969
Feng, Ching-chiou	1969
Bader, Robert	1969
Odell, Eugene	1969

Principal Research Accomplishments

Development of the Point Matching Method

The point matching method is a mathematical technique for the solution of numerous problems found in the physical and engineering sciences which have technical application. Typical of the problems which the method can be applied to are the determination of stresses, deflections, vibration frequencies and buckling loads for plates and shells and other elastic bodies; heat transfer; fluid flow; and electrical and magnetic field problems. The development of the method began here in 1959 and was subsequently supported by several contracts through the technical laboratories of the U. S. Air Force. Numerous faculty and graduate students have contributed in its evolvement, resulting in approximately 40 graduate student theses and dissertations, major technical reports, and papers presented and published internationally.

A Study of Continuum Vibrations

For the past five years a survey of the field of vibrations of continuous bodies has been sponsored in the department by NASA. This consists of locating, procuring, digesting the technical literature of the world as it relates to frequencies and mode shapes of free vibrations of structural elements such as rods, beams, membranes, plates, shells, and three-dimensional bodies. This information is being summarized in a series of monographs being published by the U. S. Govt. Printing Office. These monographs will aid engineers who have need for vibrations results and researchers in developing methods of analysis. A first monograph dealing with the vibrations of plates and covering approximately 500 references has already been published, and one on the vibrations of shells involving approximately 800 references is currently in preparation.

Analysis of Fibrous Composite Materials

Mathematical methods of determining internal stresses and displacments, and overall elastic constants have been developed for analyzing fibrous composite materials. These materials consist of continuous fibers such as glass or boron imbedded in a bonding material such as resin to form sheets or laminates are then joined to form layered plates and shells. The micromechanics problem of analyzing the behavior of the composite materials as affected by the size, shape and spacing of fibers has been investigated as well as the behavior of laminated structures to provide useful methods of designing such structures.

Experiments in Vibrations and Impact

A laboratory facility has been developed for experimental studies of vibration and impact phenomena. A wide range of topics have been investigated, including effects of magnetic fields on structural vibrations, dynamic thermoplasticity, high velocity gouging, stress wave transmission into rock, parametric vibrations and musical acoustics. Special devices or methods have been developed for imparting impulsive loads to massive structures and for measuring vibrations by reflected laser light.

Analysis of Sonic Phenomena

Sonic vibrations have found wide application in industrial processes involving drilling, cutting, welding, metal deformation and friction alleviation. Research in this area has been directed toward a fundamental understanding of sonic transducers and sonic processes. Areas studied have included transducer and transmission line resonance characteristics, effects of load on resonance, energy storage and dissipation in sonic systems, energy transfer by impact coupling and by intermittent contact, transducer transient behavior, rock drilling

and energy propagation in curved transmission lines.

Stability of Structural Elements

Contributions have been made in the study of the stability of common structural elements such as strings, columns, beams, plates and shells under dynamic loadings. Work has been doen for elastic materials (metals for example) and for materials whose properties change with time (plastics, concrete, metals at high temperature, etc.). Significant new phenomena have been brought to light, and the implication of these in practical situations have been studied both theoretically and experimentally. The results of these studies have found considerable application, particularly in the aerospace and the power industry.